Piezoresistive properties of low-firing temperature thick-films on steel sensors

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Aim of this project: Characterization of two steel sensors based on low-firing thick-film technology
- High-performance pressure sensors using high-strength ferritic, austenitic and martensitic stainless steels
- Force sensor used in total knee arthroplasty (TKA) surgical operations, based on a high-strength medical-grade austenitic stainless steel

Thick-film process sequence:
- Reduce the firing temperature to avoid degradation of the steel mechanical properties: a series of thick-film materials systems (dielectrics, resistors and conductors) firing at temperatures <700°C has been developed for ferritic / martensitic steels and compared to the high temperature commercial TF system.
- Materials interactions between resistor, conductor and dielectric are controlled using top dielectric with Al₂O₃ filler.
- For the LTTF system, to avoid high resistance for short resistors, the conductor layer has been fired @ 500°C

High strength pressure sensor
- Based on a monolithic membrane structure
- 3 TF system used on 3 substrates material:
  - A commercial TF system fired at 850°C on a special high temperature resisting ferritic steel, denoted HT
  - A low fired TF system fired at 625°C on the martensitic 17-4PH steel
  - A low fired TF system fired at 625°C on the austenitic A286 steel

Comparison between the new low temperature TF system and the commercial high temperature one on the same (HT) steel
- Both system give linear and reproducible responses but higher for the low temperature TF system
- The drifts @ nominal pressure are very low but more scattered for the low temperature TF system, due to stresses induced by tightening

Response & drift of 17-4 PH sensors compared to HT sensors
- The low temperature TF system gives comparable response on both 17-4 PH & HT steels
- Very low drifts but a little scattered on both steel with the low temperature TF system
- Sensor bodies manufactured through different techniques: MIM, machined

Response & drift of A286 sensors compared to HT sensors
- The low temperature TF system gives a similar response on both A286 & HT steels
- Very low drifts but a little scattered on both steels with the low temperature TF system

Ligament balancing sensor for total knee arthroplasty (TKA) operation
- Medical alloys chemically similar to A286
- Thick-film system used for austenitic substrate

Thickness knee sensor cell (3 force sensing bridges by parts)